

# Air-sea Fluxes: OCEAN-model needs from Re-analyses

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## Ocean analyses

- Sensitivity to surface forcing estimates

## Air-sea Flux Products

- Some new products
- Comparison with re-analyses
- Buoy data

## Atmosphere & Ocean Re-analyses

- Workshop recommendations
  - Ongoing Analysis of the Climate System (August 2003)
  - Coupled Data Assimilation Workshop (April 2003)

- Surface Fluxes have a significant impact on ocean estimates, even in assimilation mode
- Important for ocean reanalysis - paucity of the historical ocean obs

### Assimilation Sensitivity Tests

Poseidon V4 quasi-isopycnal ocean model,  $1/3^\circ \times 5/8^\circ \times 27$  layers

“quasi-global” : (no Arctic Ocean)

Assimilation scheme: OI

Sensitivity: forcing + treatment of salinity

Period: 1993-2003

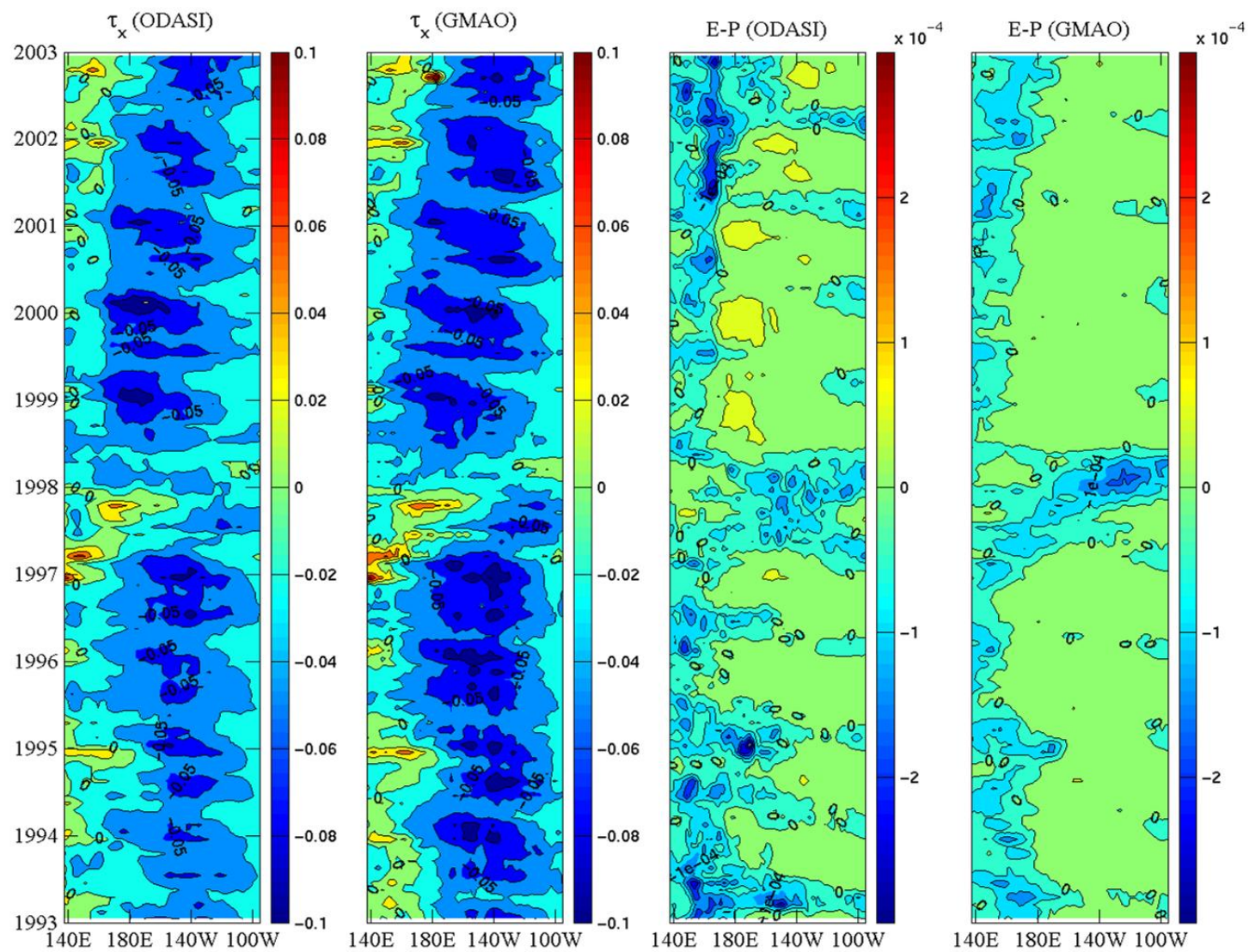
### Surface Forcing

ODASI forcing:

- NCEP CDAS forcing, wind stress climatology replaced by Atlas/SSM/I analyses - relaxation to Reynolds weekly SST and Levitus salinity.

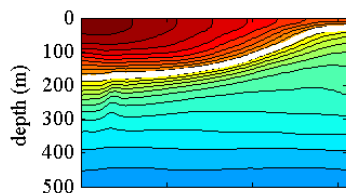
GMAO forcing:

- Atlas/SSM/I time varying wind stress
- GPCP monthly mean precipitation
- NCEP CDAS SW (for penetrating radiation) & LH (for evaporation)
- relaxation to Reynolds SST

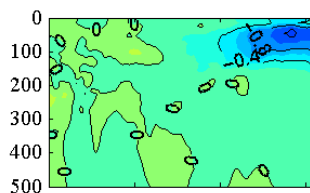


GMAO-TS

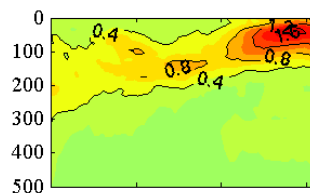
Mean Temp



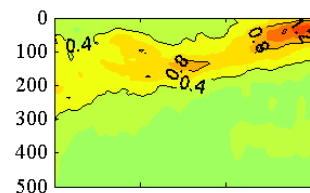
Mean diff



RMSD

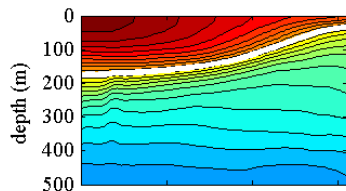


STD diff

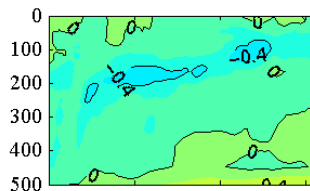


ODASI-T

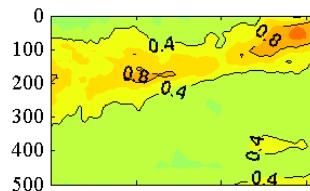
Mean T: ODASI-T



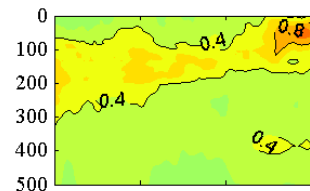
Mean difference



RMSD

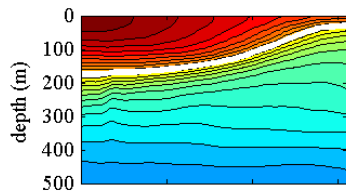


Diff STD

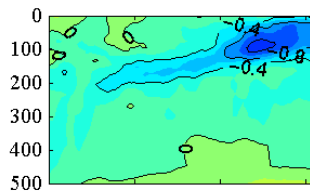


GMAO T

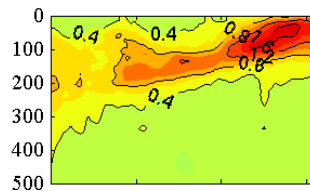
Mean T: GMAO-T



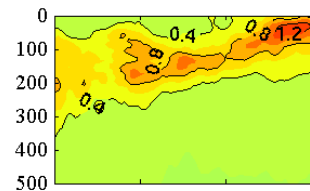
Mean difference



RMSD

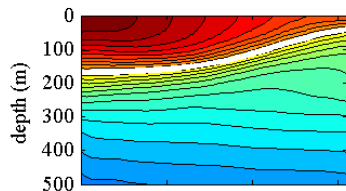


Diff STD

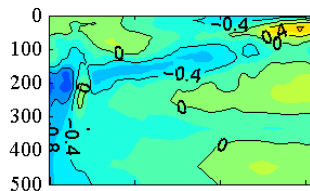


GFDL

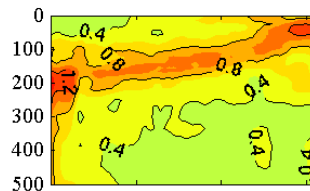
Mean T: GFDL



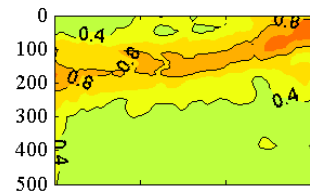
Mean difference



RMSD

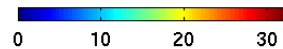
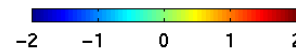
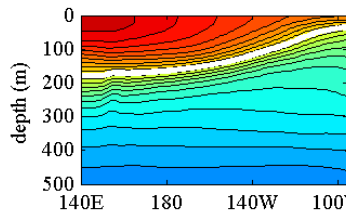


Diff STD



ODASI-TS

Mean T: ODASI-TS



# Surface Flux Product Comparisons

- NCEP1
- GFDL - NCEP2/CDAS
- CORE (NCAR - Large & Yeager)

Common Ocean-ice Reference Experiments for CLIVAR/WGOMD

<http://data1.gfdl.noaa.gov/nomads/forms/mom4/CORE.html>

- WHOI (OAFlux - Yu & Weller)

Objectively Analyzed air-sea FLUXes

<http://oaflux.whoi.edu/data.html>

- ERA-40

## Large & Yeager (2004)

- Use Bulk formulae -- use Ocean Model SST (vs observed SST)
- Correct fields so that long-term mean fluxes are in balance
- Turbulent fluxes - shift temperature and humidity to height of wind - shift coefficients to this height and atmospheric stability
- Radiative fluxes - use consistent products for both components (cloud compensation)
- Precipitation data - highly uncertain - need breakdown in terms of rain and snow
- Runoff (distributes net P-E over land into runoff)
- Relaxation to observed SST - negative feedback helps contain the accumulation of flux errors
- Precipitation does not depend on salinity - no feedback to contain the flux errors
- Ice-ocean fluxes - use a sea-ice model

- NCEP; ISCCP
- Precipitation - blend of GPCP (tropics) and Xie-Arkin (GPCP/Serreze data in polar regions)
- SST and SSS data sets for relaxation

### Flux corrections:

- SW (ISCCP c.f. other products)
- Qscat → corrections in wind speed
- LH → corrections in specific humidity → changes to P
- Global imbalances reduced to  $1 \text{ Wm}^{-2}$  and  $-0.1 \text{ mg/s/m}^2$



# Qnet Seasonal Means

WHOI

NCEP1

GFDL

CORE

Dec/Jan/Feb

Min, Max: -435, 249.

Dec/Jan/Feb

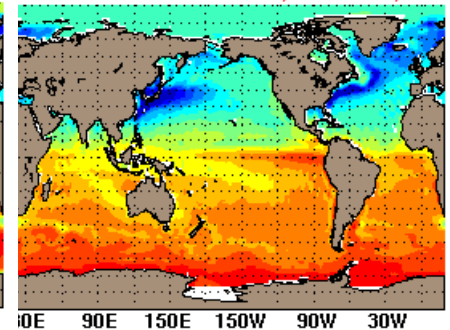
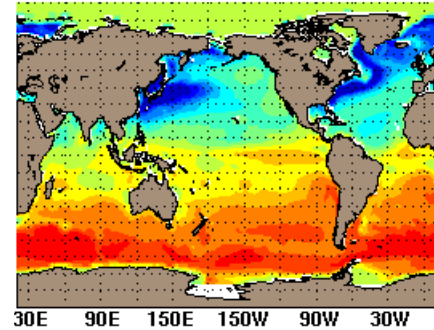
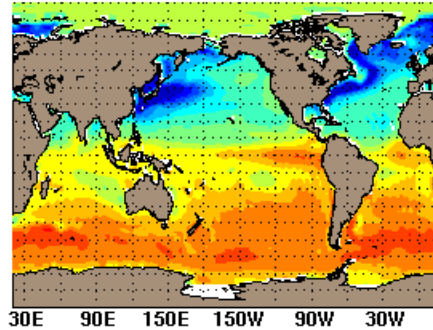
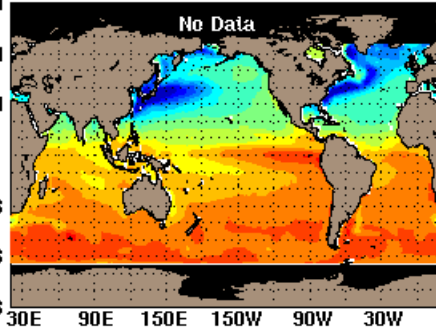
Min, Max: -442, 210.

Dec/Jan/Feb

Min, Max: -502, 249.

Dec/Jan/Feb

Min, Max: -446, 245.



Jun/Jul/Aug

Min, Max: -243, 219.

Jun/Jul/Aug

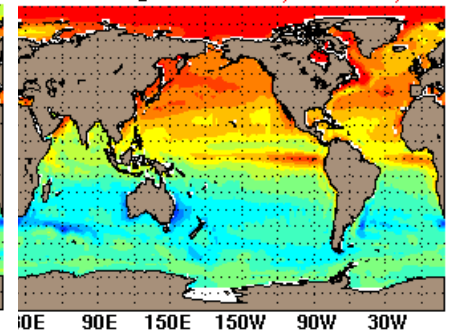
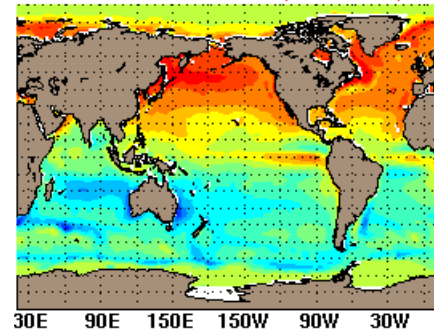
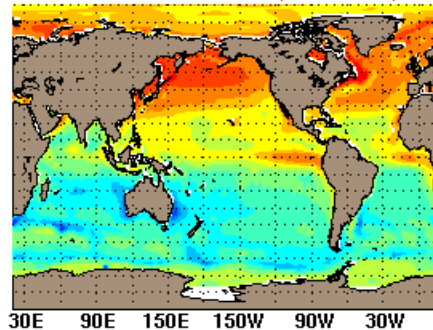
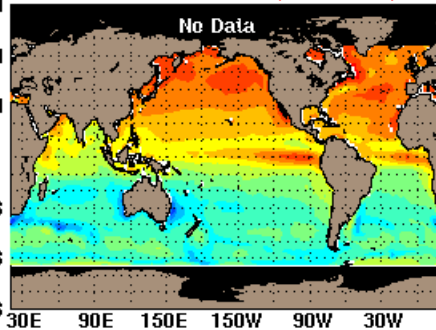
Min, Max: -239, 223.

Jun/Jul/Aug

Min, Max: -268, 246.

Jun/Jul/Aug

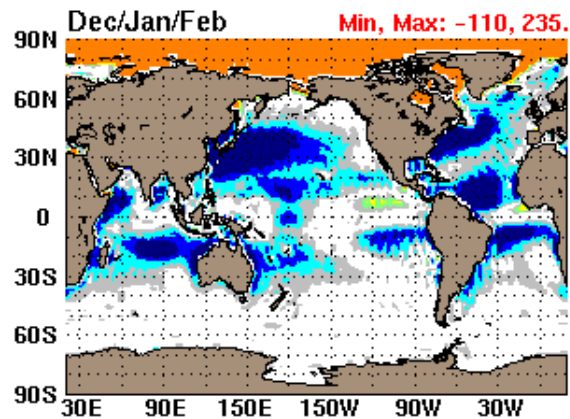
Min, Max: -306, 237.



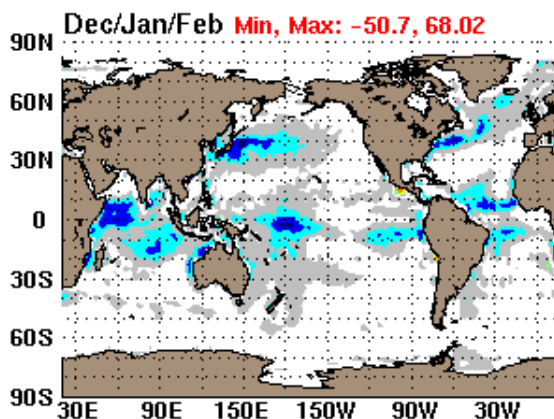


# Latent Heat Flux Differences Seasonal Mean

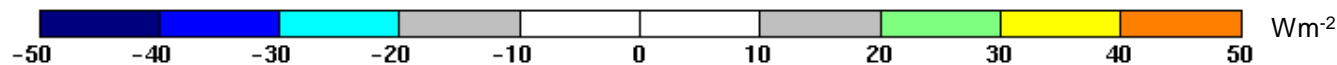
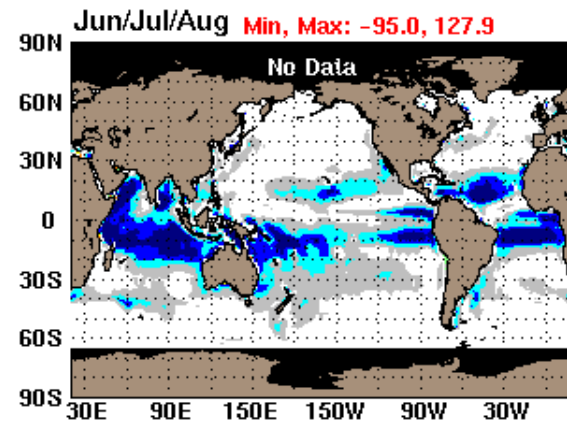
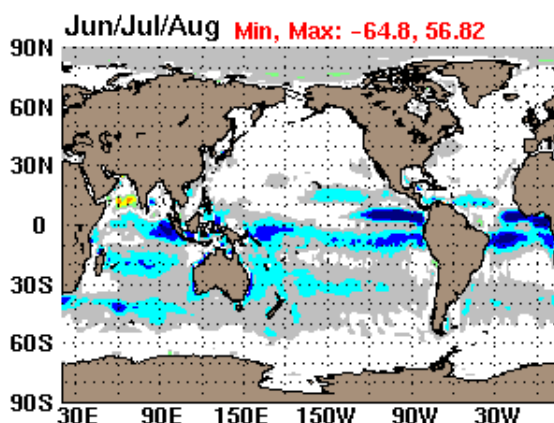
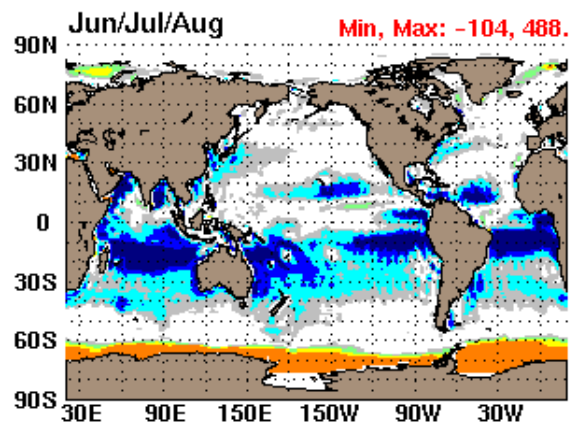
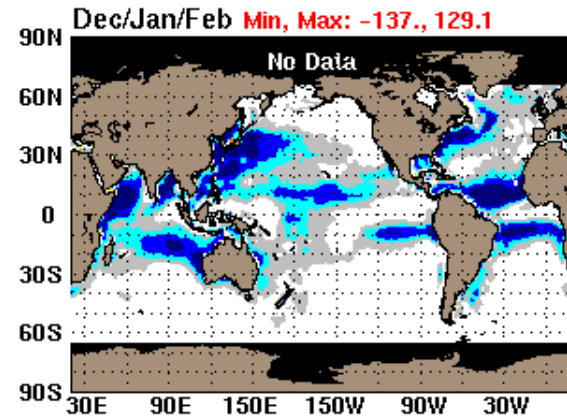
GFDL - CORE



GFDL - NCEP1

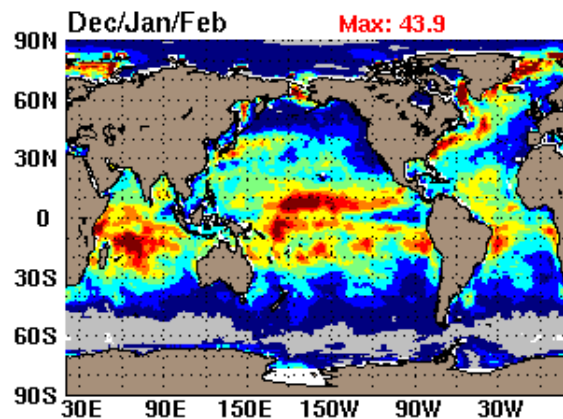


GFDL - WHOI

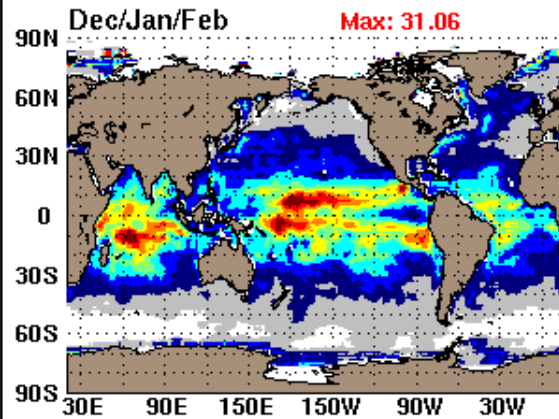


# Latent Heat Flux Differences Seasonal STD

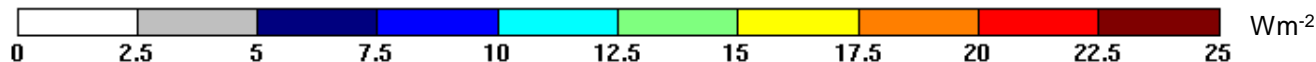
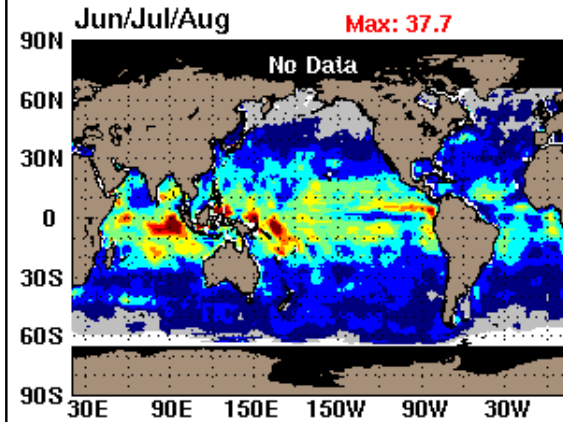
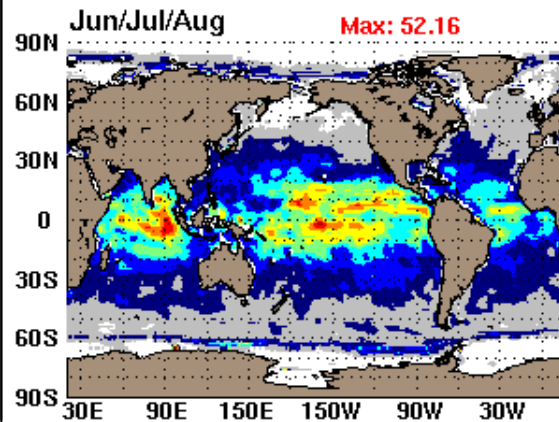
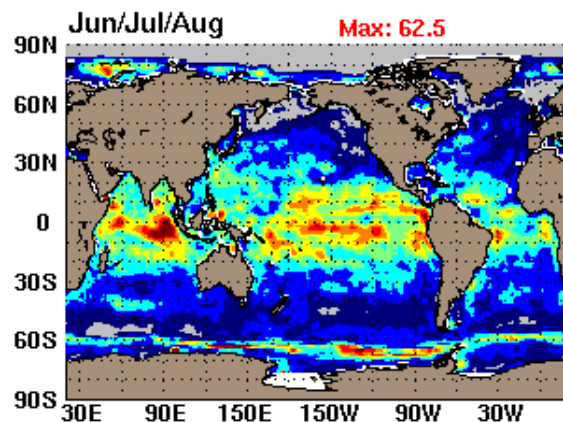
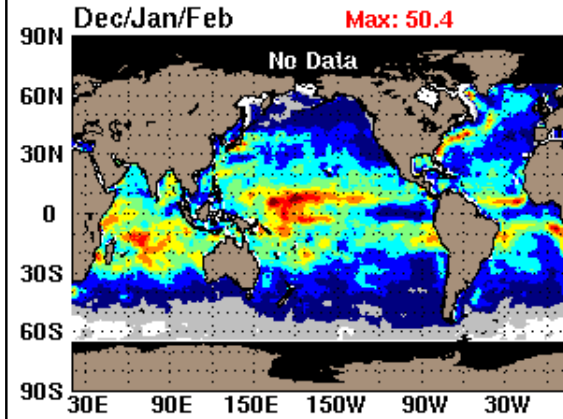
GFDL - CORE



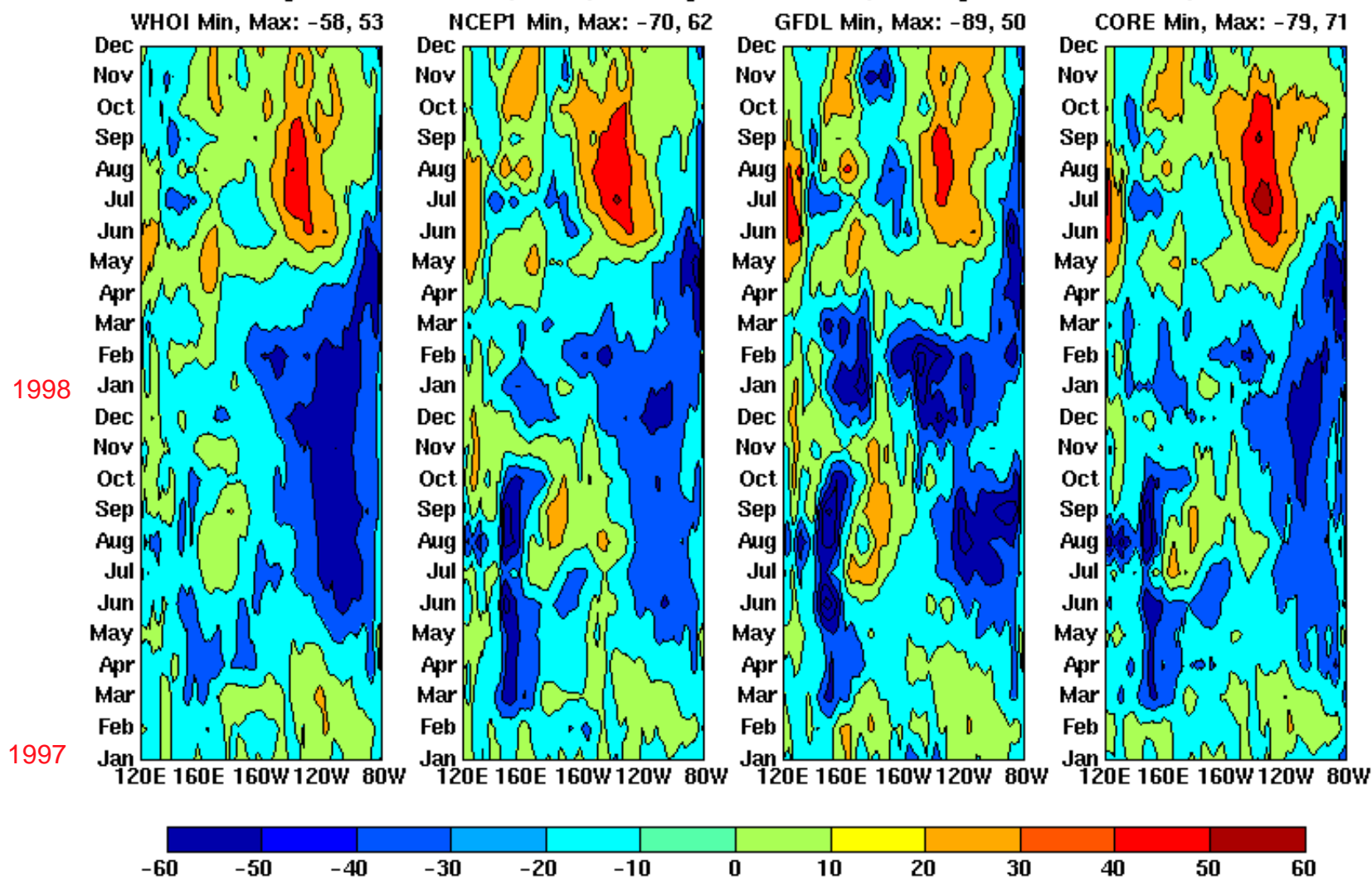
GFDL - NCEP1



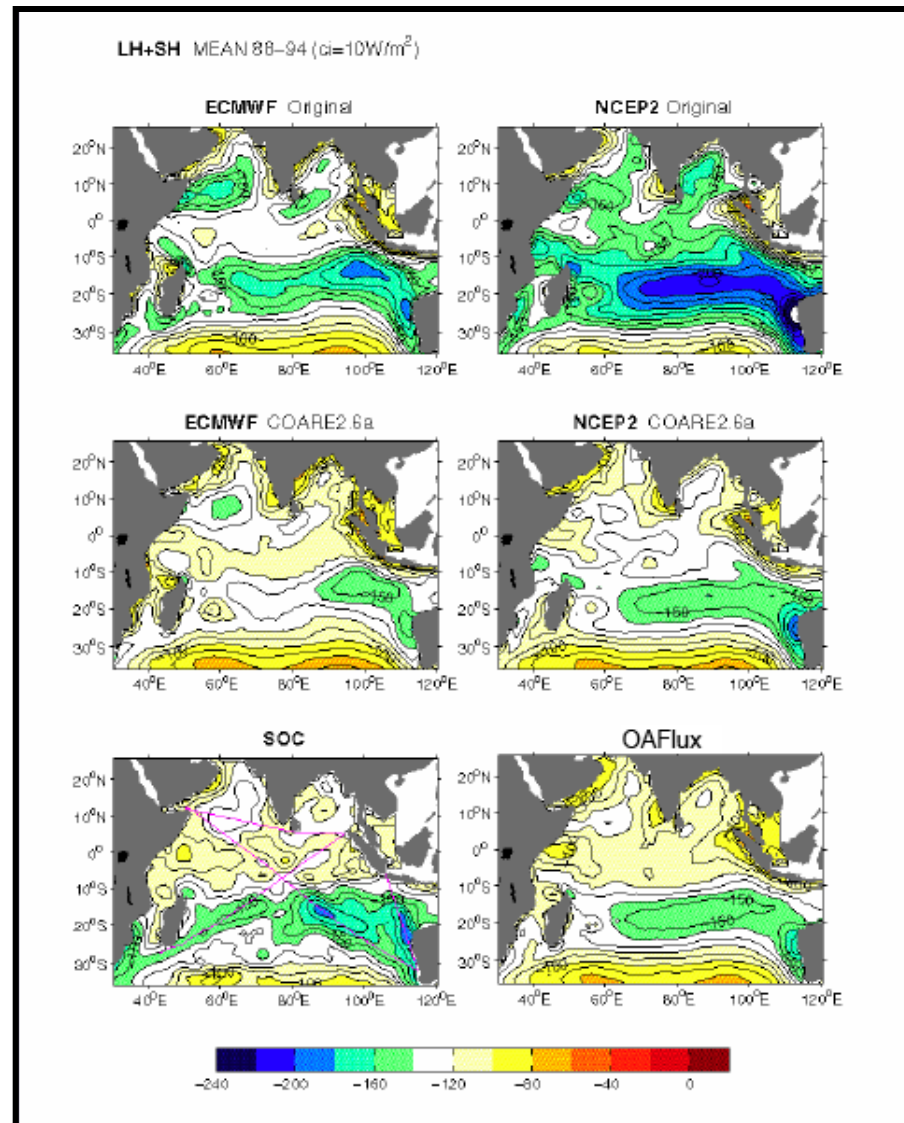
GFDL - WHOI



# Changes in Qlh+Qsh ( $\text{W/m}^2$ ) During 1997–1998 (Average over 5S to 5N)



Why is it difficult to get the flux correct? Data? Algorithm?

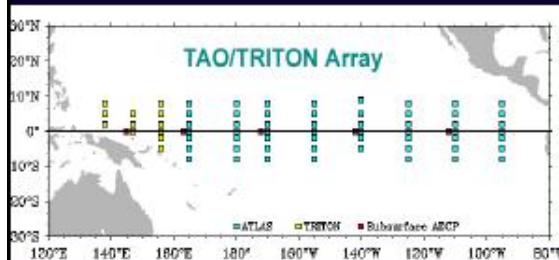




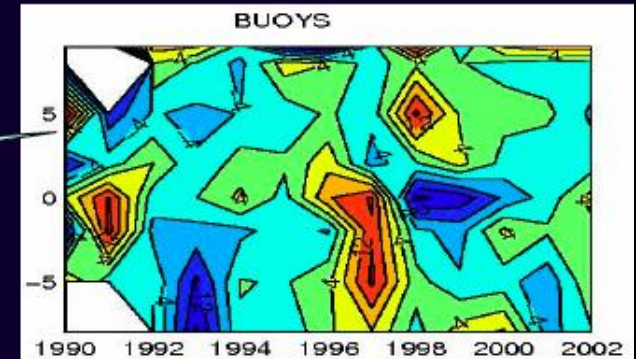
# Problems in model humidity



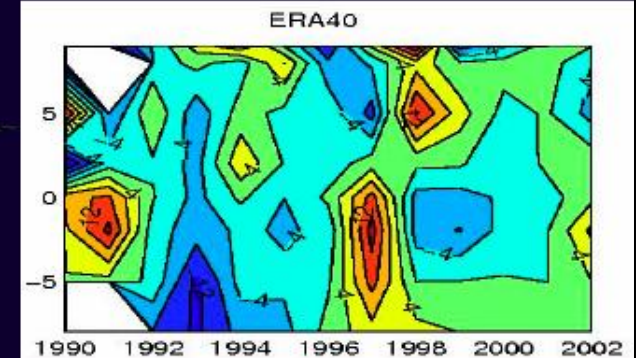
Year-to-year variations of zonally averaged latent heat flux from TAO buoys and ERA40



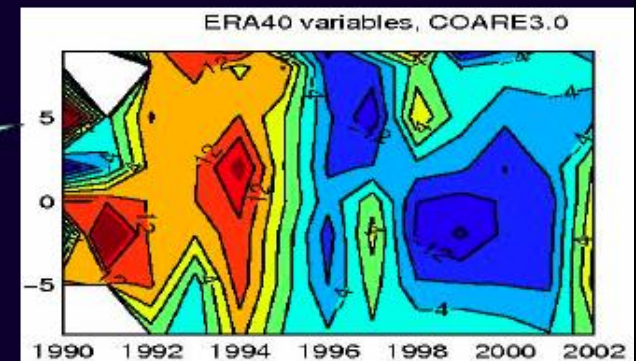
Buoy  $Q_{LH}$



ERA40  $Q_{LH}$



ERA40 variables  
COARE algorithm



Positive (negative) flux anomalies indicate more (less) latent heat loss from the ocean.

# Ongoing Analysis of the Climate System: A Workshop Report



August 18-20, 2003  
Boulder, CO  
Sponsored by NOAA, NASA & NSF

## Surface Flux Panel

### Background:

- Fluxes between the atmosphere and the ocean, land surface, sea-ice are important for understanding climate variability
- Surface forcing is a major source of error and uncertainty for ocean and land surface products
- Need better products and information on error statistics as input to ocean and land surface data assimilation

### Findings :

- Current Reanalysis surface flux products are not adequate for climate analyses (not accurate, budgets don't close) or to force ocean and land surface models (not accurate).
- Of particular note: significant biases in precipitation and radiation.
- We need **accurate surface fields** more than accurate fluxes so that we can **calculate our own surface fluxes**. We replace reanalysis fields with corrected fields or other observational analyses (such as satellite-based surface radiation) when needed. Corrections for humidity are problematic.

### Recommendations (1):

- Atmosphere, Ocean, Land Surface, Sea-ice analyses and the fluxes for each should be “synchronized” - coordinated programmatically
- Atmospheric analyses for climate purposes (such as CDAS) should be kept current
- Analysis should be best estimate of the state - that's what we measure
- Surface analyses should encompass:  
realistic variability in the modern era down to 1 degree resolution globally,  
resolving diurnal cycle

### Recommendations (3):

- R&D priorities:
  - Improve cloud & PBL (atmosphere and ocean) representations so that analyses can produce realistic fluxes.
  - Develop assimilation for coupled systems
  - Improve assimilation methods so as to use surface observations more effectively



# Coupled Data Assimilation

NOAA/OGP-funded Workshop, 21-23 April 2003

**How should the problem be approached from theoretical and practical aspects? What are the first steps that could/should be taken?**

- A loosely coupled system is the proper first step (NCEP, FNMOC)
- An incremental approach (e.g., atmosphere coupled to mixed layer; hybrid coupled models)

## Summary

- Need better products and information on error statistics as input to ocean data assimilation
- Need long time-series and for analyses to be kept current
- Need consistent analyses of atmosphere and ocean - Coupled?
- Requirements (SCOR, Taylor, 2000): high quality flux products, 3hrly, 50km, errors of a few  $Wm^{-2}$ , consistency and continuity